AN INTEGRATED PROCESS AUTOMATION AND MANAGEMENT SYSTEM ON A DAIRY EXPERIMENTAL FARM

J.M.F.H. Achten, H.J.J. Janssen, R. Bijkerk, G.H. Kroeze and F.H. Ettema

DLO Institute for Agricultural and Environmental Engineering (IMAG-DLO), P.O.Box 43, 6700 AA Wageningen, The Netherlands, telephone +31 317 476423, fax +31 317 425670, E-mail j.m.f.h.achten@imag.dlo.nl

Abstract: A new process automation and dairy management system (MS-DVR) has been developed for the experimental farm of IMAG-DLO. MS-DVR is developed for the operational control of the dairy herd, the management of dairy farming research projects and the data handling of research experiments. The hardware is based on standard industrial components and the computer application is developed with LabVIEW software. The functionality of the commercial management system UNIFORM is integrated in MS-DVR to one flexible, reliable and user-friendly process automation and management system. In the newly developed system, much attention is paid to the collection, processing, storage and retrieval of experimental data collected on the experimental farm in a research database (RDD).

Keywords: process automation, management information system, research databases

1. INTRODUCTION

The dairy farming experiments of the DLO Institute for Agricultural and Environmental Engineering (IMAG-DLO) are mostly carried out on the experimental farm 'De Vijf Roeden' in Duiven, The Netherlands, about 40 kilometer from Wageningen. The research focuses on sensor applications, the early detection of oestrus and mastitis, milking machinery experiments, data acquisition of NH3 and the like. In the past decade, IMAG-DLO developed a process automation and data acquisition system, based on a central computer (DEC-PDP 11/xx). The application was written in the computer language Fortran-77. All data communication cables and measuring devices, needed for individual cow-identification, provision of roughage, water and concentrates and several sensors for data collection were directly connected with the central computer and caused a mass of

cables. This situation caused complex hardware -maintenance problems and this situation too often resulted in measuring errors and disturbances. Also the maintenance of the software became very complicated, because the application consisted of a great number of computer modules, developed by different research workers. The technical documentation was a weak point in most applications and the addition of new functionality to the software often resulted in much extra developing time to trace and solve bugs. The collection of data was mostly organized by the research workers themselves and the data were stored on different places, in different formats and were only accessible by the researcher involved. On the experimental farm much research is carried out with sensors and electronic equipment of third parties. The connection of these devices to the process automation system has always been a very specialized operation and only few researchers knew the software in detail.

In 1994 the above described problems became so urgent that it was decided to develop and implement a completely new and integrated system for process automation, operational management of the herd and management of dairy farming experiments and data collection. In this paper the development, implementation and results of MS-DVR are described.

2. CONCEPTUAL DESIGN

The following starting points were formulated for the functional design of the new concept (Achten & Janssen, 1994):

- MS-DVR should support 1) the operational (day to day) dairy herd management, 2) the management of the dairy farming experiments and 3) the management of the collected data;
- The process automation units and measurement devices have to be installed on distributed, industrial hardware placed in the houses as closely as possible located to the processes;
- The process automation units have to be controlled by one 'master'. The input data for the proses automation units should be entered on this master and the progress of the processes, controlled by all units has to be viewed also on the master. If the physical connection between the master and the units is lost, the units should control the processes with the last entered cow-settings;
- The features of a commercial cow herd management system have to be integrated;
- The software of MS-DVR has to be developed with a modern, graphical software tool and the addition of new functionality should be implemented very efficiently;
- Much attention should be paid to the collection, reliability, evaluation, storage and security of research data.

3. IMPLEMENTATION

In Figure 1 a schematic view of the technical (or hardware) implementation of MS-DVR is presented. Sensors and actuators connected with Process Control Units (PCU) are installed for controlling the following processes: 1) provision of concentrates, 2) provision of roughage, 3) provision of water, 4) provision of milk to calves 5) milking and 6) cow traffic around the automatic milking system and 7) measurement of the level of NH3-concentration, inside and outside weather climate conditions and soil conditions of the grassland parcels.

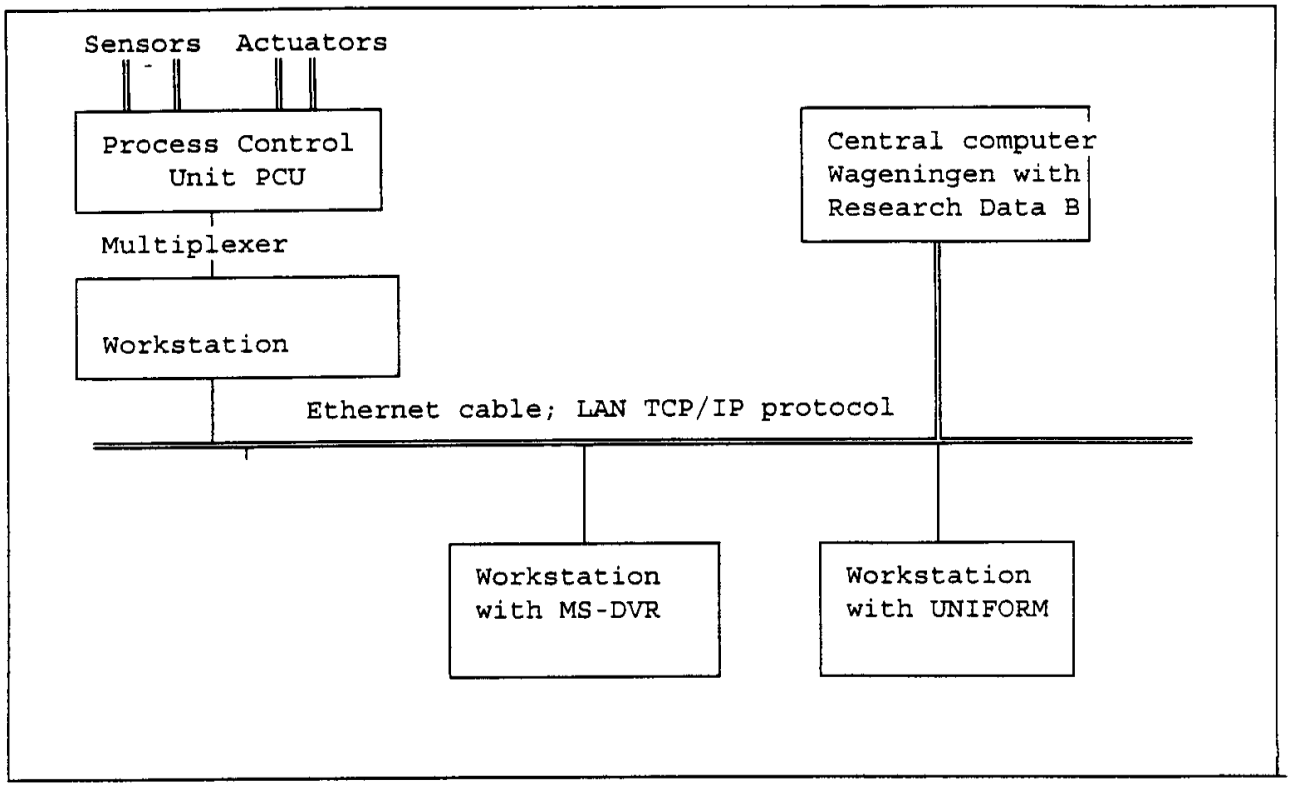

Figure 1: Schematic view of the technical implementation of MS-DVR on the experimental farm 'De Vijf Roeden' at Duiven

A working group with researchers of several disciplines and staff management of the experimental farm has defined the functional specifications of MS-DVR. For the mentioned processes the measuring and controlling algorithms were defined with required input variables. The data, which should be collected including data formats, were specified. Much attention was paid to the definition of hardware alarming situations including level of severity. The global specifications of the user interface, the graphical presentations, listings, etc. were also defined. The above-mentioned requirements were specified in internal reports.

3.1 Process Control Units

The hardware required for electronic cow identification, sensors, actuators and other data acquisition devices are located in the houses and installed as close as possible to the processes to reduce the mass of cables substantially. In each house a PCU is installed and each PCU consists of an intelligent multiplexer and a workstation. The multiplexer contains the hardware and software for data-acquisition and control of sensors and actuators respectively. On the workstation the control algorithms and a real-time database are implemented. The individual cow identification system is installed on the multiplexer. The process automation and data acquisition software is written in LabVIEW, a so called SCADA programming package. In the multiplexer only industrial standard Input/Output components are applied, which give the best guarantee for easy replacement and updating of components in case of hardware faults or increased demands for I/O devices. Bitbus

protocol is used for the communication between multiplexer and workstation (PC with an Intel 486 processor). The NEDAP cow identification system is applied and installed under the VC4 protocol. The conductivity of the milk of each quarter of an udder is measured by a sensor of NEDAP in the milk claw. The milk yield and milking speed are measured by weighing the milk recorder jars each five seconds. The milk temperature is measured by a device included in the sensor used for conductivity measurements. The cows are equipped with an activity tag; the activity meters are read out on all locations with an electronic device (milking parlours, concentrate boxes).

All measure and control algorithms as well as required input parameters are stored in the memory of the workstation. Each workstation has sufficient internal memory and storage capacity to operate during at least seven days with full functionality, even if the connection between PCU en the Master-PC has been broken. In that situation, the provision of concentrates and roughage to individual cows is controlled on the basis of the last passed individual cow-settings. As soon as the connection is repaired, new rations from MS-DVR are passed to the PCU and the collected data are sent to the database of MS-DVR. Much attention is also paid to the early detection of alarms and aberrations in the PCU's. If, for example the concentrate system does not function, an alarm will appear immediately with a certain colour on the screen of the concerning PCU; the same alarm is also presented on the master.

3.2 Management System MS-DVR

The overall 'management' of the PCU's is carried out by one 'master'. This master-PC contains the software for operational control of the dairy herd, the management of dairy farming research projects and the data handling of research experiments. Only on the master-PC, the parameters for the experiments, like assigning of cows to feeding groups and individual cow settings can be entered; the parameters are distributed immediately to the databases of the PCU's. MS-DVR is installed on a PC with an Intel-Pentium processor. On the master-PC the software which supports the above-mentioned management functions is installed. The total system is called MS-DVR. MS-DVR contains two subsystems: MS-DVR-Operational and MS-DVR-Research. The software for the management of the third system (data handling of research experiments) is installed on the central computer of IMAG-DLO in Wageningen. The cluster MS-DVR-Operational and the PCU's are responsible for the operational management of the dairy herd. MS-DVR-Operational takes care for the two-way data communication to pass cow-settings and research parameters to and collected data from the PCU's. The software of MS-DVR-Operational is realized with LabVIEW. The capacity of the database of MS-DVR-Operational is sufficiently to store the data of at least two weeks.

MS-DVR-Research contains the experimental computer modules which are subject of dairy farming research. Also the additional required data and data processed by special expert systems or statistical modules are stored in the database of MS-DVR-Research. The experimental modules are strictly divided from the operational dairy herd management system. In the past, the performance of some experiments was influenced by bugs in one or more experimental modules. The communication between MS-DVR-Operational and MS-DVR-Research is based on the exchange of flat ASCII files. A one-way communication is established between MS-DVR-Research and the Research Database (RDD), located

at the central computer of IMAG-DLO at Wageningen.

3.3 UNIFORM

For the operational control of the dairy herd the features of the commercial management system UNIFORM are integrated as much as possible (Silva, 1995). UNIFORM is installed on a separate PC, connected to the Ethernet-LAN. The feed ration calculations, milk planning, herd reports and other standard reports are produced by UNIFORM. The herdsmen use UNIFORM for the registration of the daily observations, illness and the like.

Also in MS-DVR-Research feed ration calculation routines are available and in some experiments they overrule the rations of UNIFORM. Between MS-DVR-Research and UNIFORM a two-way data communication based on the ADIS protocol (ISO, 1992) has been realised. ADIS are the abbreviation of Agricultural Data Interchange System. The actual figures of cows, stored in the database of MS-DVR-Research are used as input for UNIFORM to produce additional herd reports.

3.4 Research Database (RDD)

Cow experiments are mostly quite complex operations and often include a mixture of new or adapted sensors, new or adapted actuators and new or adapted control programs, etc. The collected data represent high costs and it is often very difficult or even impossible to execute the same experiment under the same conditions. Therefore, much attention is paid to the collection, validation and storage of research data. For that purpose a database has been created which contain all data, collected during experiments. The RDD is installed on the central computer in Wageningen and contains all data, collected at the experimental farm in Duiven (Research Database Duiven). The large storage capacities, very fast backup facilities, advanced communication and retrieval facilities for the research workers, who are mostly working in the main office, are the main reasons to install the RDD in Wageningen. The access to the database is granted only to privileged research workers, based on a data security system. The RDD is programmed with the RDBS language ORACLE. At midnight a loading process is activated on the master-PC, which collect the data files from MS-DVR-Research and UNIFORM. These data files are sent over the AGRONetwork to Wageningen where other automatic procedures store the data files in the RDD. The detailed process data (five seconds data) are written to tape; the labels of the tapes are stored in the RDD.

4. RESULTS

In autumn 1995, three PCUs' were installed for 1) the provision of concentrates, roughage, water and milk, 2) the automation of the milking parlour and 3) the control and registration of the cow traffic around the automatic milking system. Also, new data acquisition equipment and cow identification system in the houses were installed. Initially, the data communication with the hardware and software of third parties delivered problems, but these problems have been solved. Within two seconds a cow is identified, the feed algorithms in the PCU have compared the actual status of the cow with the required rations and if necessary, the PCU has sent a control command to the concentrate boxes, roughage boxes, etc. to provide the next portion of feed, the give access to the concentrate box, etc.

In early spring of 1996, MS-DVR-Operational was implemented with full data

communication facilities between the PCU's and MS-DVR-Operational. Additional herd attention lists are generated by the MS-DVR-Research. The implementation of the hardware alarms on the PCU's is not fully implemented yet, but will be carried out before summer 1996.
The data communication between the databases of MS-DVR-Operational and MS-DVR-Research is already installed and we are working on the re-engineering of existing software modules for data screening, mastitis detection and other expert programs. We are also still occupied with the development of additional retrieval and processing modules of the RDD. A part of the database is already in operation as well as the procedures to store data files from MS-DVR-Research and UNIFORM automatically in RDD. Facilities for retrieval and processing are already developed but not complete yet.

5. CONCLUSIONS

The development and especially the implementation of an integrated concept for process automation, operational dairy herd management and a management system for research experiments was a very time consuming operation. Nevertheless, we are convinced that the experimental farm of IMAG-DLO is well equipped for the performance and management of high qualified research experiments.
We have also the opinion, that this concept can be applied on other experimental farms of research institutes, universities and R&D farms of commercial enterprises.
The high integration of process automation and operational dairy herd management as installed on the experimental farm of IMAG-DLO, can be considered as the first prototype for the next generation of commercial dairy herd management and process automation systems. In these new generation systems, expert and monitoring modules are built in as standard facilities and require on-line data communication between management and process automation systems.

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